Australian Root Zone Soil Moisture: Assimilation of Remote Sensing Observations

J.P. Walker[a], N. Ursino[b], R.B. Grayson[a] and P.R. Houser[c]

[a]Department of Civil and Environmental Engineering, University of Melbourne, Parkville, Australia
j.walker@unimelb.edu.au

[b]Department IMAGE, University of Padova, Italy

[c]Hydrological Sciences Branch, NASA Goddard Space Flight Center, Greenbelt, United States

Abstract: Knowledge of temporal and spatial variation in root zone soil moisture content across Australia is vital for a wide range of environmental and socio-economic activities. However, such information is not currently available, due to an inability to monitor with ground-based point measurement techniques at an appropriate spatial resolution, and the uncertainty associated with land surface model predictions. Advances in remote sensing instruments and algorithms have made possible monitoring of spatial variation in surface soil moisture content for areas of low to moderate vegetation, but these measurements are limited to the top few centimetres at most. While soil moisture measurements for such a thin surface layer are not very useful on their own, this surface data is used to constrain land surface model predictions through the process of data assimilation, yielding improved estimates of soil moisture not only in the surface layer, but also at depth. The C-band passive microwave remote sensing data from the Scanning Multi-frequency Microwave Radiometer (SMMR) is assimilated into a land surface model for the period 1979 to 1987. We are limited to this time period as there has been no appropriate space-borne passive microwave sensor from then until May 2002, when the Advanced Microwave Scanning Radiometer for the Earth observing system (AMSR-E) was launched. Moreover, SMMR has the same frequencies as AMSR-E making it an ideal developmental test bed until AMSR-E data become available. The disadvantage of the SMMR time frame is the lack of adequate soil moisture validation data, meaning that it is difficult to assess the improvement of skill in predicting root zone soil moisture content when surface observations are assimilated. We assess the improvement in skill by comparing with patterns in Normalised Difference Vegetation Index (NDVI) data and the limited soil moisture profile data available.

Keywords: *Soil Moisture; Land Surface Modelling; Remote Sensing; Data Assimilation*

1. INTRODUCTION

Knowledge of spatial and temporal variability in root zone soil moisture across Australia is crucial in a wide array of environmental fields. Such applications range from weather and climate prediction to early warning systems (e.g. flood forecasting), climate-sensitive socio-economic activities (e.g. agriculture and water management) and policy planning (e.g. drought relief and global warming). However, reliable information on root zone soil moisture content at the continental scale is not currently available for a variety of reasons. First, there is a limited area that can be monitored with an adequate spatial and temporal resolution using ground based point measurement techniques (Grayson and Western, 1998). This stems from the large variability in soil moisture content and soil properties over short distances (Western et al. 1999, 2002), and the cost involved with installation, calibration and maintenance of soil moisture monitoring equipment. Second, there is a high level of uncertainty associated with continental scale land surface models, with a wide variation between the different models when using the same input parameters and atmospheric forcing (Houser et al., 2002).

Advances in passive microwave remote sensing have made possible the measurement of soil moisture content over large areas on a frequent basis under certain conditions. While this would appear to be an obvious alternative for gaining knowledge of spatial and temporal variation in soil moisture content across Australia, there are a few limitations. For instance, this only provides a soil moisture estimate of the top few centimeters at most and is limited to areas of low vegetation (Du et al., 2000, Engman 2000) away from large water bodies such as the ocean. Moreover, due to the relatively weak signal observed, space borne sensors have a coarse resolution, being on the order of 25km. While this resolution is appropriate for broad scale applications such as weather prediction and policy planning, it is not appropriate for small scale applications such as on-farm water management. Further, surface soil moisture measurements are highly dependent on the meteorological conditions of the last few hours to days, and do not give a direct indication of the more relevant deeper layer soil moisture content. Thus methods for obtaining root zone soil moisture content from these surface measurements need to be developed. While there have been numerous synthetic experiments demonstrating such a capability through assimilation of these surface measurements into a land surface model (eg. Entekhabi et al., 1994; Walker and Houser, 2001; Reichle et al., 2001), there have been relatively few studies that have used real space-borne data.